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Experimental Study of Wall Roughness Effect on Frost Formation over a Cylinder

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1. Introduction

Frost formation is a common phenomenon in the industrial and household heat exchangers. The frost develops when a humid air comes into contact with a cooler surface then to its freezing point. This phenomenon improves the performance of heat exchangers due to the increase of surface of the heat transfer at the start of process. But with the lapse of time, the frost acts as insulation causing a drop in heat transfer and performance of the system. Frost action is a fundamental problem contributing to the instability of infrastructure embankments in regions of seasonal ground freezing, and often results in railway and highway engineering difficulties.

In this study, wall roughness effect on frost formation over a cylinder is investigated.

2. Experimental setup

Figures 1 and 2 illustrate the system designed in this experiment. It consists of a test section, a channel with a large cross section, a diffuser, a turn, and a channel with small cross section connecting to air chamber that includes: fan, heater, and humidifier.

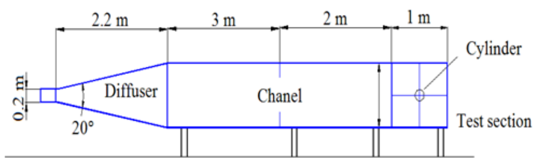

Fig. 1. Side view of the wind tunnel apparatus

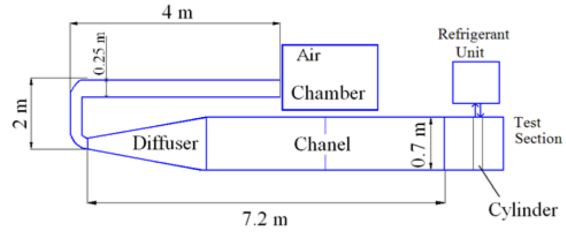

Fig. 2. Plan view of the wind tunnel apparatus.

Cooling system includes a ¾ hp compressor functioning with R502 coolant. Evaporator is a cylinder which measures 16 cm in outer diameter. The outer cylinder is Aluminum of thin plate which measures 0.2 mm in thickness and covers the evaporator channel. The evaporator channel is a 35 m copper tube that was coiled and fitted around a hollow aluminum cylinder. The inner surface of the hollow cylinder is fully insulated by yonolit.

3. Results and Discussion

Fig. 3 shows the frost thickness in front of steel cylinder for n=50. According to Fig. 3, as cylinder temperature decreases, frost thickness increaseses because mass and temperature potential increases.

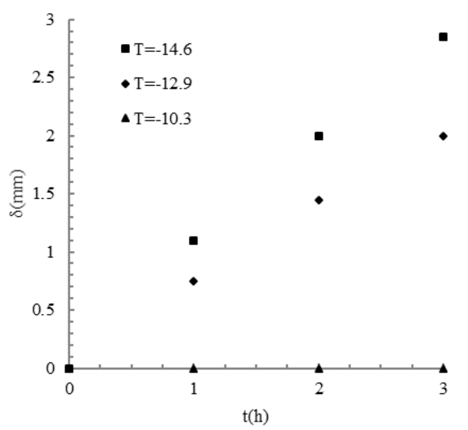

Fig. 3. Frost thickness in front of steel cylinder for n=50.

According to Fig. 4, as wall roughness increases, frost thickness increases.

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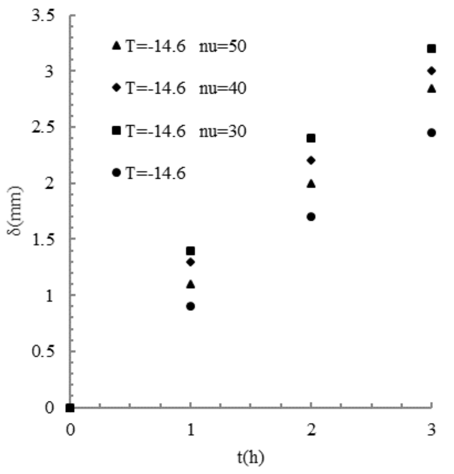

Fig. 4. Frost thickness in front of steel cylinder for different wall roughness.

Fig. 5 shows frost thickness for different wall roughness and thermal conductivity coefficient. Further increasing the wall roughness, the frost thickness increases and increasing the thermal conductivity coefficient of rough surface, raises the frost thickness too.

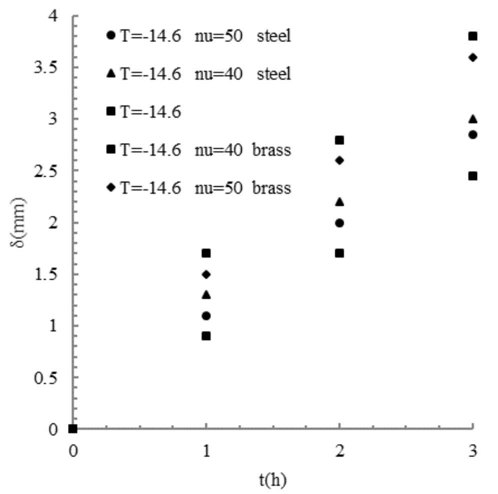

Fig. 5. Frost thickness in front of cylinder for different wall roughness and thermal conductivity coefficient.

4. Conclusion

In this study the wall roughness effect on frost formation over a cylinder frost on horizontal cylinder in force convection conditions was investigated experimentally. The effects of cold surface temperature, the number of meshes and different material on frost thickness were studied. The obtained results show:

- As wall roughness increases, frost thickness increases too.
- As the thermal conductivity coefficient of wall increases, the frost thickness also increases.
- In front of cylinder, the frost thickness is minimum and at the behind of cylinder it is maximum.